Micromagnetic simulation for probabilistic magnetization switching process of a spin-orbit true random number generator

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Abstract: True random number generator (TRNG) is an important component for modern information security technologies. Among the candidates, TRNG with spin-orbit torque (SOT)-induced probabilistic magnetization switching is competitive for its advantages in anti-radiation, unlimited endurance, robust stability, and broad temperature range. However, realization of a SOT-TRNG requires intensive understanding of the magnetic dynamic process under a spin-orbit current. Here, we performed micromagnetic simulation of the SOT-induced probabilistic magnetization switching by using Mumax 3. Without thermal noise, identical magnetic moment precessions were found between repeated simulation cycles, resulting in deterministic magnetization switching. When thermal noises were taken into account, stochastic precession trails and thereby probabilistic magnetization switching were finally obtained. Our results suggest the Mumax 3 to be a practical tool for simulating the probabilistic magnetization switching behavior of a SOT-TRNG, as well as highlighting the crucial role of thermal noise during the during the simulation.

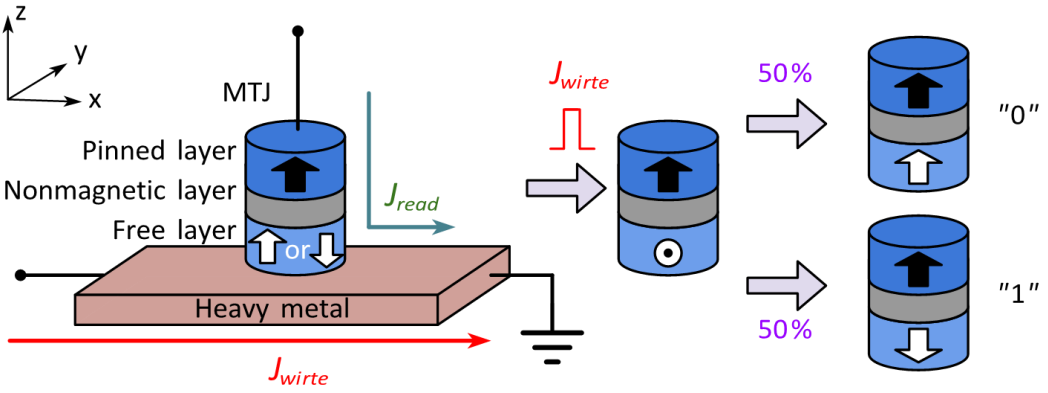

Figure 1. Schematic drawing of the SOT-TRNG

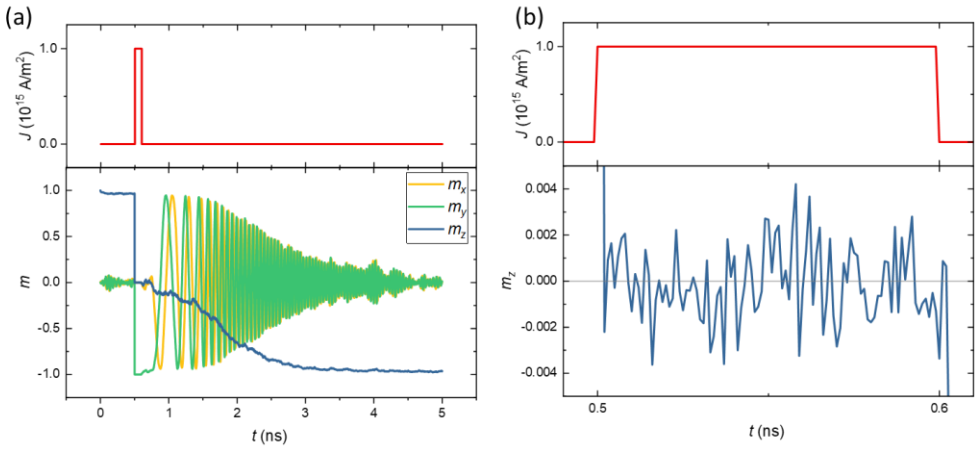

Figure 2. Current-induced magnetization switching process without thermal noise. Identical deterministic switching were obtained for repeated simulation cycles.

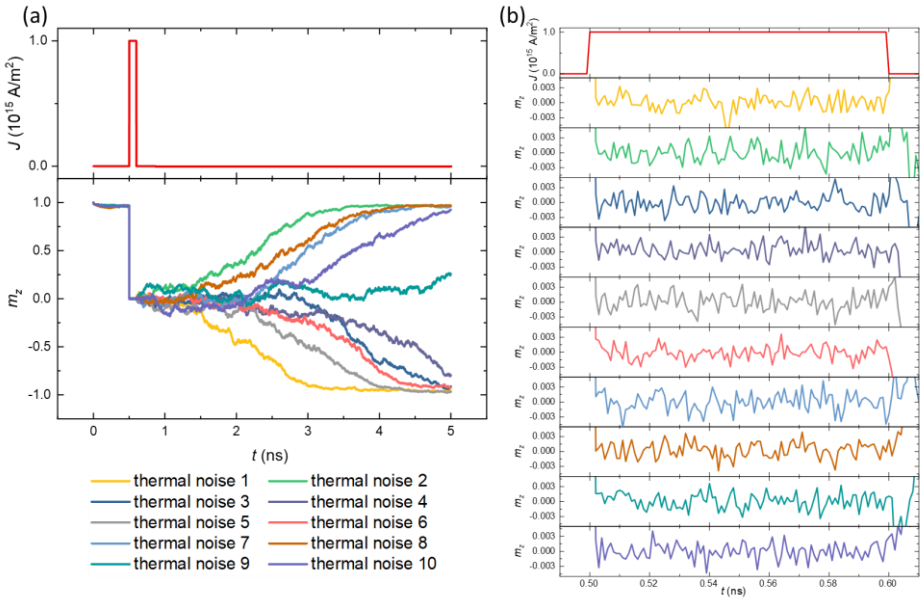

Figure 3. Current-induced probabilistic magnetization switching with thermal noises.